Distribution and ecology of *COMPSOPOGON COERULEUS* (Balbis) Montagne (Rhodophyta, Bangiophycideae) in Eastern Spain

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RÉSUMÉ. – L'étude de 60 collections d'eau de l'est de la péninsule ibérique, de Malaga aux Pyrénées, pendant les années 1979-80, nous a permis d'observer, chez six d'entre elles, la présence de *Compsopogon coeruleus* (Balbis) Montagne. Dans trois de ces stations (faiblement limnocrènes) l'algue est présente pendant route l'année, tandis qu'elle manque dans deux stations littorales en hiver. Les récoltes faites dans le canal sont uniquement hivernales.

Nous précisons les coordonnées des six stations suivant le «1000 meter universal transverse Mercator grid» et nous donnons une brève description du milieu avec quelques notes sur les macrophytes qui accompagnent l'algue. Les caractères morphologiques de l'algue sont très proches de ceux déjà décrits par divers auteurs. Il semble que *Compsopogon coeruleus* soit légèrement sciaphile : il a été trouvé dans des eaux chaudes (15,6-28°C), douces et saumâtres (jusqu'à 7000 microS.cm^{-1} de conductivité). L'augmentation de la salinité et la diminution de la température sont les causes de l'absence de l'algue dans les lagunes littorales pendant l'hiver. La forte salinité, le pH stable (7,5-8) et la saturation en oxygène sont trois caractérisriques communes aux six stations. Le rapport N/P est très élevé dans toutes les localités sauf dans le canal où la concentration de P est très forte.

ABSTRACT. – *Compsopogon coeruleus* (Balbis) Montagne is recorded from six localities in Eastern Spain. Three of them are springs and the alga can be found there all the year round. The rest are two coastal lagoons and a canal.

A description of the morphological characters of the specimens is given. So as the exact geographical co-ordinates of the stations and a short description of the habitat and accompanying species. Data on temperature, conductivity, pH, alkalinity, nutrients and major ions are commented.

INTRODUCTION

During 1979 and 1980 over 60 water bodies have been sampled along the Spanish Mediterranean coast, from Malaga (Southern Spain) to France. Such waters included salt pans, marshes, coastal lagoons, springs (limnocrenes), canals and reservoirs. *Compsopogon coeruleus* (Balbis) Montagne 1846 has been recor-

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ded from six points : a canal, two coastal lagoons and three springs. In all of this places the alga was growing profusely.

Compsopogon Montagne 1846 shows a worldwide distribution in tropical and subtropical waters (KRISHNAMURTHY, 1962). Several species have been reported from Europe but only in sparce way and in very limited conditions. In warm water aquaria the following species have been recorded : *C. aeruginosus* (J. Ag.) Kütz. in Germany (MÜLLER, 1960); *C. hookeri* Montagne also in Germany (HEYNIG, 1971); *C. chalybeus* Kütz. in Italy (BATTIATO *et al.*, 1979); and *C. coeruleus* Mont. in Czechoslovakia (ZANEVELD *et al.*, 1976).

In natural waters *C. corinaldii* (Meneghini) Kütz. was first recorded in Italy in 1840 (DE TONI, 1897) and later by LUSINA (1943); and in France in 1883 (BOILLOT, 1958). *C. chalybeus* Kütz. was found by POVOA DOS REIS (1960) in a stream from Portugal, 15 km far from the sea. *C. hookeri* Mont. was registered in Germany by FRIEDRICH (1966). The first reports of *C. coeruleus* Mont. came from an English canal near Manchester (WEISS & MURRAY, 1909). This report was confirmed and recorded again by KRISHNAMURTHY (1962). In France, BOILLOT (1958) cited the alga in a stream in the South, near Banyuls-sur-Mer. BATTIATO *et al.* (1979) cited it from Malta, in a canal. This station disappeared later as the canal was drained out. FERRER & COMIN (1980) recorded in 1975 and 1976 *Compsopogon* as very common in Ebro Delta, NE Spain. Although the species was then not positively determined, it has been revised and identified as *C. coeruleus* Mont.

Actually *Compsopogon coeruleus* is known from a wider area in East Spain, lasting the whole year in full vegetation. This paper comments some morphological features of the species, its distribution and ecological factors. Water samples for analysis were fixed *in situ*. The major elements and nutrients were analyzed following the methodology after STRICKLAND and PARSONS (1968) adapted by MARGALEF *et al.* (1976). Conductivity and salinity were measured *in situ* with a YSI-Meter and pH by a pH-Meter E488 Metrohm Herisau.

MORPHOLOGY

All specimens from the stations sampled show a morphology quite similar to the description given by KRISHNAMURTHY (1962). *C. coeruleus* is a filamentous alga, bluish-green or dark violet in color. Thallus from 15 up to 42 cm long. Principal axis erect, more or less branched, 0.5 to 5 mm wide. Thalli often show outgrowths, spine-like in some old ones, up to 1 mm long and random distributed over the thallus. Filaments are attached to substrata that include *Phragmites* roots and macrophyte stems, by means of uniseriated rhizoids forming a basal plate 90 to 115 microns in section. Uniseriated branches 12-46 microns in width. They consist of discoidal or cylindrical cells more or less swollen, 12 to 46 microns wide and 3.5 to 23 microns long. Apical cells from these branches are conical or semiglobose. As the main axis, older branches have one to several cortical cell layers; cells being polygonal and surrounding the large axial cells or the place left by them, measuring between 11.5 and 43

Figure. – Distribution of *Compsopogon coeruleus* (Balbis) Montagne in the East coast of Spain. ▨ Sampling area, ● Localities cited.

microns the greatest dimension and 6 and 20 microns the shortest one.

Many parietal chromatophora resemble rounded granulations, oblong to much elongated. In the oldest filaments where the axial cells have collapsed the inner cortical cells are highly swollen, taking spherical shape. In such filaments, chromatophora are sparse and few. Eventually some of the cortical cells show small outgrowths invading the inner hollow. The apical parts of these outgrowths are cap-like. The limit of axial cells are marked externaly by constrictions of the thallus, sometimes very profound and coinciding with transversal cell walls. These constrictions persist even after the collapse of the axial cells. In young branches with lighter cortication and in old filaments of some specimens numerous, finger-like outgrowths consisting of cortical cells are present, growing towards the filament base, in the opposite direction of the branches. These digitations never set apart from the cortex and grow recumbently over adjacent cortical cells.

Very old filaments loss color and take a waxy texture, turning stiffer and delicate. Eventually some young filaments grow upon the old ones. Monosporangia measure about 20 microns, although in some specimens larger or smaller diameters have been observed. Epiphytes are quite common on the filaments, chiefly on the oldest ones.

DISTRIBUTION AND ECOLOGY

Compsopogon coeruleus is recorded from six points representing a wide area of Eastern Spain. All stations are near the coast and some are connected to the sea. Following are the exact localities, referred to 1000 meter universal transverse Mercator grid, and short descriptions of the habitats :

1. – Santa Pola (Alicante) UTM : 30S-YH0528. In Azarbe de Dalt Canal. Waters from irrigation fields. It is 5 km far from the sea and measures 4 m in width and 2 m in depth. The plant was very abundant, filaments reaching a large size and a deep violet hue, growing upon large specimens of *Potamogeton pectinatus*. This station was visited in 24-II-80, and was not sampled in other dates.

2. – Pego (Alicante) UTM : 30S-YI5307. In a small spring in a marshland area, called Marjal Mayor. The spring water upwells from the bottom. The alga was recorded all year round (1979, 1-V, 3-VIII, 14-XI; 1980, 26-II). Accompanying vegetation consisted of *Potamogeton pectinatus*, *P. nodosus*, *Myriophyllum spicatum*, *Najas marina*, *Ceratophyllum demersum*, *Apium nodiflorum* and *Enteromorpha* sp.

3. – Jeresa (Valencia) UTM : 30S-YI4221. In a small spring similar to the number 2, from the zone called La Marchal. *Compsopogon* was observed all the seasons of the year (1979, 2-V, 4-VIII, 14-XI; 1980, 26-II). Accompanying vegetation consisted of *P. pectinatus*, *P. nodosus*, *M. spicatum*, *C. demersum*, *Lemna trisulca*, *Nymphaea alba*, *Chara aspera*.

4. – Vinaroz (Castellón) UTM : 31T-BE8280. In a small coastal lagoon extended perpendicularly to the sea shore, originated by Rambla (= temporary sream) de Oliva. A rocky shore separates the coastline from the lagoon, which is 20 m away from the sea. The alga was found all the year, except in winter (1979, 6-V, 9-VIII, 17-XI). Accompanying aquatic plants were : *P. pectinatus*, *P. pusillus*, *P. coloratus*, *Ruppia maritima*, *Chara major* and *C. baltica*.

5. – Amposta (Tarragona) UTM : 31T-BF0605. A small spring similar to numbers 2 and 3, in a marshland called Pla del Notari, just in the limit of Holocene deltaic sediments and Pleistocene conglomerates. *Compsopogon* was found the 23-VII-79, but this station was not sampled in other seasons. Accompanying vegetation was : *P. pectinatus*, *P. coloratus*, *M. spicatum*, *M. verticillatum*, *C. demersum*, *L. trisulca*, *L. minor*, and *Utricularia vulgaris*.

6. – Camarles (Tarragona) UTM : 31T-CF0617. In a typical coastal lagoon in the Ebro Delta called Les Olles. It was found the 13-IX-79; the station was not sampled in other dates. Accompanying vegetation : *P. nodosus*, *P. pusillus*, *C. demersum*, and *Enteromorpha* sp. This lagoon is fed with water from the rice fields before harvest.

From a physical point of view these water bodies can be grouped in three springs (stations 2, 3 and 5), a canal (station 1) and two coastal lagoons (stations 4 and 5).

Temperature in springs is almost constant all over the year (table I) and remain between 17.5 and 28°C in summer. Mineralization of waters used to be quite variable, and station 3 stands out for its relatively low conductivity, close to 500 microS.cm^{-1} during all the year. Stations 2 and 5 have a higher conducti-

Table I. — Extreme values of temperature and conductivity

St.	T °C	Cond. microS.cm^{-1}
2	17.5 - 23.0	1220 - 1500
3	17.8 - 22.0	465 - 600
4	10.0 - 28.0	3000 - 7000
5	19.0	1689
6	24.0	

Tableau II. — Mean values of pH and major constituents

St.	pH	Alc. meq.l^{-1}	Cl^- meq.l^{-1}	SO_4^{2-} meq.l^{-1}	Ca^{2+} meq.l^{-1}	Mg^{2+} meq.l^{-1}	Na^+ meq.l^{-1}	K^+ meq.l^{-1}
1	8.2	6.76	75.50	69.62		9.83		0.40
2	7.8	3.39	13.55	2.21	5.92	2.16	8.07	0.19
3	7.5	4.43	1.34	1.64	5.58	2.42	0.87	0.03
4	7.8	4.31	49.82	9.34	16.73	13.99	34.86	0.54
5	7.1	6.40	9.43	1.70				
6	7.8	3.42	4.44					

Tableau III. — Mean concentrations of nitrate-nitrogen, phosphate-phosphorus, reactive silicate and oxygen saturation

St.	$N.NO_3^-$ mg.l^{-1}	$P.PO_4^{3-}$ mg.l^{-1}	Si_r mg.l^{-1}	Ox. % saturation
1		1.2849	5.886	
2	1.771	0.0063	2.985	117
3	2.602	0.0047	4.408	87
4	6.328	0.0052	3.034	138
5	1.037			

vity, about 1400 microS.cm^{-1}, with small fluctuations along the year (table I). In stations 4 and 6 the degree of mineralization is much higher and so is the annual fluctuation, differing within 3000 and 7000 microS.cm^{-1}. Qualitative composition of the water in station 3 indicates a typical fresh water where most important ions are bicarbonate and calcium (table II). In other stations concentration of sodium and chloride are higher, showing the influence of sea water. High alcalinity, strong buffer capacity and stable pH are common to all the stations. Average values for pH are between 7.5 and 8, and in all the stations the maximal observed variation is of ± 0.5 pH units. Alkalinity is also much stable over the year, and for every point the highest variation is ± 1 meq.l^{-1}. The ratio between $SO_4^=$ and other anions is always high, and its concentration differs within 2 meq.l^{-1} (approx. 100 mg.l^{-1}) in springs and 9.3 meq.l^{-1} (= 450 mg.l^{-1}) in station 4. Well oxigenated waters is present in all the points, the saturation level being over the 83 per cent, and in summer reaching oversaturation values in all stations except number 3.

Phorphorus contents usually are lower than 0.015 mg.l^{-1}, values typical for mesotrophic waters, although for the station 1 P-$PO_4^{\equiv}$ content at the time of sampling was 1.29 mg.l^{-1}, a value very high even for eutrophic waters.

Silica concentration is between 2.10 and 4.60 mg.l^{-1}, and the largest fluctuation is about 1.5 mg.l^{-1}.

The nitrogen content is always high and varies in a very remarkable way. During spring and summer all values are very similar, ranging between 0.92 and 1.15 mg.l^{-1} N-NO_3^-. In fall concentration rises, reaching in winter the highest value for the year. In springs this increment is about 100 per cent, while in coastal lagoons it can be higher (COMIN & FERRER, 1979).

DISCUSSION

Compsopogon coeruleus is spread over a wide area along the eastern coast of Spain. Climatologicaly Mediterranean, this coast (Levante) differs from further northern and southern coasts having gentle winds and droughts and very mild temperatures.

Morphological and developmental characters are consistent with data published by others authors, although specimens have been found much larger than recorded, up to 5 mm in width and 42 cm in length. Moreover, in some material from station 3, old thalli showed spine-like outgrowths up to 1 mm long, few in number and randomly distributed along the thallus, and consisting of several cortical cells. This character was already signalled in specimens from Ebro Delta (FERRER & COMIN, 1980). *C. coeruleus* was found in fresh and brackish waters, up to 7000 microS.cm^{-1}, in a wide spectrum of conditions. Physical and chemical properties may be from relatively stable to strongly seasonal, and coastal lagoons are subjected to marine influence. So in points 4 and 6, the alga was not found in winter, when the water temperature drops and salinity increases as masses of sea water have entered the lagoons since fall. The alga was not present in other water bodies sampled during the year, with wider annual fluctuations. In springs 2 and 3 *Compsopogon* never vanished,

although in winter it was less frequent and the specimens showed decoloration. In these points average temperature is high (19°C) and mineral content is low (table II).

Filaments of the alga are attached to different substrata as rock, water lily petioles and leaves, *Potamogeton* stems, etc. Incident light seems to be important, and the alga behaves as a moderate shadow plant. The largest specimens came from a canal rich in nutrients (point 1). The very effect of current and nutrients as well must influence the size of filaments. Similarly, the leaves of *P. pectinatus* that served as support for the alga, attained in this canal a size uncommon for the species.

In all the stations nitrogen content was in excess of 0.92 mg.l^{-1} $N\text{-}NO_3^-$. The ratio between nitrate and phosphate was always over 100/1 expressed in microg·at.l^{-1}. Only in station 1 the ratio was lower.

It can be said that *Compsopogon coeruleus* is well established in Spain in water bodies of different properties, and that populations are not incidental. It would be interesting to check further its distribution over larger areas and long time persistence of the alga.

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